

EVALUATION OF
THE FIRST FIVE-YEAR OUTLOOK ON SCIENCE AND TECHNOLOGY

FINAL REPORT
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I. Introduction: A Seminar for Evaluation of the Five-Year Outlook

A. Participants

Six faculty, seven undergraduates, and three graduate students (including three auditors) joined Daryl Chubin (a sociologist of science), Fred Rossini (a physicist/philosopher of science), and advisor Melvin Kranzberg (an historian of technology) in PST 8549 (The Status and Future of U.S. Science and Technology -- A Policy Evaluation), during the Spring 1980 quarter at Georgia Tech. The faculty were recruited for their expertise in select areas addressed in the Outlook, with the emphasis being on technology and applied science rather than basic science (see II). The faculty included a mechanical engineer, a health physicist/nuclear engineer, a materials scientist, a health systems analyst, a computer scientist/logician, and an applied policy analyst/psychologist. The students represented a cross-section of science, engineering, architecture, and management fields. (See Appendix A for a complete directory of faculty and student participants in the seminar.)

Besides these local participants, the course benefitted from the commentary of various distinguished visitors: NSF/STIA's Dr. William Blanpied, Tech President and National Science Board member, Dr. Joseph Pettit, NSF/SRS's Dr. Robert Wright, and University of Oregon physicist/science policy analyst, Professor Michael Moravcsik,

B. Orientation and Evaluation Procedure

As Dr. Blanpied and President Pettit reminded us at the inaugural seminar, the Outlook materials were generated in response to a Congressional mandate. To meet the legislative requirements, four documents were prepared: Volume I (an overview by NSF), and Volume II (a separately published treatise on a number

of important topics by the NRC/NAS, 1979; a collection of statements by the 21 federal agencies which account for nearly all R&D obligations; and a set of scholarly papers commissioned by NSF). These documents were circulated to all seminar participants.

The students were asked to choose two for evaluation. (Appendix B contains the schedule of topics covered and suggests the iterative approach adopted for their evaluation.) After an introductory session and three weeks of faculty briefings on each topic, three weeks were spent on draft student critiques. Each oral presentation was used as a basis for discussion and extensive group critique. Written commentary by Chubin and Rossini was provided on each draft critique. Final drafts were written cooperatively by the pair of students responsible for each topic. This constraint was imposed in the expectation that a coherent cross-disciplinary perspective on each topic would emerge. These perspectives, in turn, would contain the bases for recommendations concerning future Outlooks. As the remainder of this report indicates, our expectation, to a large extent, was realized.

C. General Critique

The following general observations were made -- both orally and in written drafts -- and endorsed with almost complete unanimity by the seminar participants.

1. The Outlook documents were inconsistent in tone and coverage. With the exception of some commissioned papers, the Outlook tends to exclude controversial topics and often read like rationalizations instead of analyses.

2. The selection of topics is not well-justified. Certain topics are treated redundantly, others ignored altogether.

3. There are definite questions about the responsivity of Outlook documents

to the legislation. In addition, the five-year time frame is generally not adhered to.

4. Too often an appeal to "further research" is proffered as "the answer" to problems in science/technology (S/T).

5. A review of past policies and their impacts on S/T development is virtually nonexistent in the Outlook.

6. There is a significant lack of social and policy science perspectives in various evaluations, particularly those by the NRC/NAS.

7. The component which communicates most effectively the purpose and results of the Outlook is the NSF overview.

In addition to these observations, we question the selection and scope of topics in the first Outlook. Certain NRC/NAS separations, e.g., health from both energy and the environment, may be justified on grounds of import, but not when discontinuities and redundancies abound in those separate chapters. Some rethinking of topics and their treatment is in order. In the evaluation that follows the strengths and weaknesses of various Outlook components are noted under each topical heading.

II. An Evaluation of Selected Topics

A. Scope

Seven topics were selected for evaluation: materials, energy, environment, health, communications/computers, academic science/graduate education, and international cooperation. Each topic was the subject of an NRC/NAS chapter. All but three topics were also the subject of at least one paper commissioned by NSF. Further, students were required to review the federal agency statements relevant to their topics. Thus, multiple perspectives on each topic were developed.

B. Topical Evaluations

The following sections present a brief commentary on the Outlook treatments of seven topics and specific suggestions on how to enhance future treatments.

1. Materials. The NRC/NAS chapter on materials is both fragmented and redundant. The styles of different authors who contributed sections to the chapter may be the culprit, but more than editing is needed.

Perhaps the most useful concept presented in the chapter is the "total materials cycle," which could be expanded as a framework for conceptualizing materials. Such a framework would help to emphasize the crucial building-block role of materials for all science and technology. One alternative framework is summarized in Table 1. Note that this framework can be used to describe a particular materials industry or materials industries in general. The phases follow those presented in the NRC/NAS chapter (1979, p. 323),

Because the materials chapter stands alone in the first Outlook, its deficiencies are glaring. Only fleeting attention is given to recycling and substitution. Federal regulations which must play a prominent role in recycling, substitution, and conservation is virtually ignored. The impact of current regulations on private industry is barely hinted at in the U.S. import table (pp. 328-329). Since our importation of many needed minerals and metals is a necessity, the political implications of our foreign dependency and lack of conservation are key short-term issues. Indeed, materials may be our next "crisis" -- after energy -- to address.

2. Energy. Treatment of this topic is uneven. The NRC/NAS chapter offers neither a "big picture" nor coherence in connecting energy issues. A schema such as Figure 1 would be an informative framework. With such a schema in mind, alterations in energy flow over the next five years can be seen to derive primarily from improved energy efficiency, less so from life-style changes, but certainly not from improvements in the raw fuel supply. Energy thus appears to be foremost an economic and political matter of implementing policies that

TABLE 1

A FRAMEWORK FOR ASSESSING THE TOTAL MATERIALS CYCLE

Phase	Major Dynamic Factors	Outlook
1. Extraction of raw materials from environment.	<ul style="list-style-type: none"> -state of the art extraction technology -governmental regulations -environmental concerns -international cooperation and economic conditions -societal demands 	<ul style="list-style-type: none"> -North-South interdependence problems -more substitution -less economic incentives and innovation -reduction in energy consumption and pollution -more multinational cooperation will move overseas
2. Processing raw materials into bulk materials.	<ul style="list-style-type: none"> -basic science <ul style="list-style-type: none"> -crystal growth -catalysis -surface physics and chemistry -energy intensive phase -capital investment in "new" technology 	<ul style="list-style-type: none"> -technology transfer will accompany move overseas -major impacts on energy consumption and international cooperation
3. Processing bulk materials into engineering materials.	<ul style="list-style-type: none"> -same as above in phase 2 -market demands -consolidation of phases 2 and 3 -quality control technology 	<ul style="list-style-type: none"> -designs needed to improve efficiency of construction of finished products
4. Fabrication of engineering materials into finished products	<ul style="list-style-type: none"> -state of the art of molding, casting, etc., technology -non-destructive quality control technology -marketing 	<ul style="list-style-type: none"> -designs needed that will improve durability and recyclability of products
5. Recycling or return of discarded material to environment.	<ul style="list-style-type: none"> -durability -conservation -environmental concerns 	<ul style="list-style-type: none"> -designs needed that will ease disassembly and sorting of recyclable products

Source: Adapted from draft critique by Charles Brown, May 1980.

provide incentives, i.e., reward efficiency and lifestyle changes (see Stoubaugh and Yergin, 1979; Shelton paper in Appendix C; and the Harry-Rhodes critique in Appendix D).

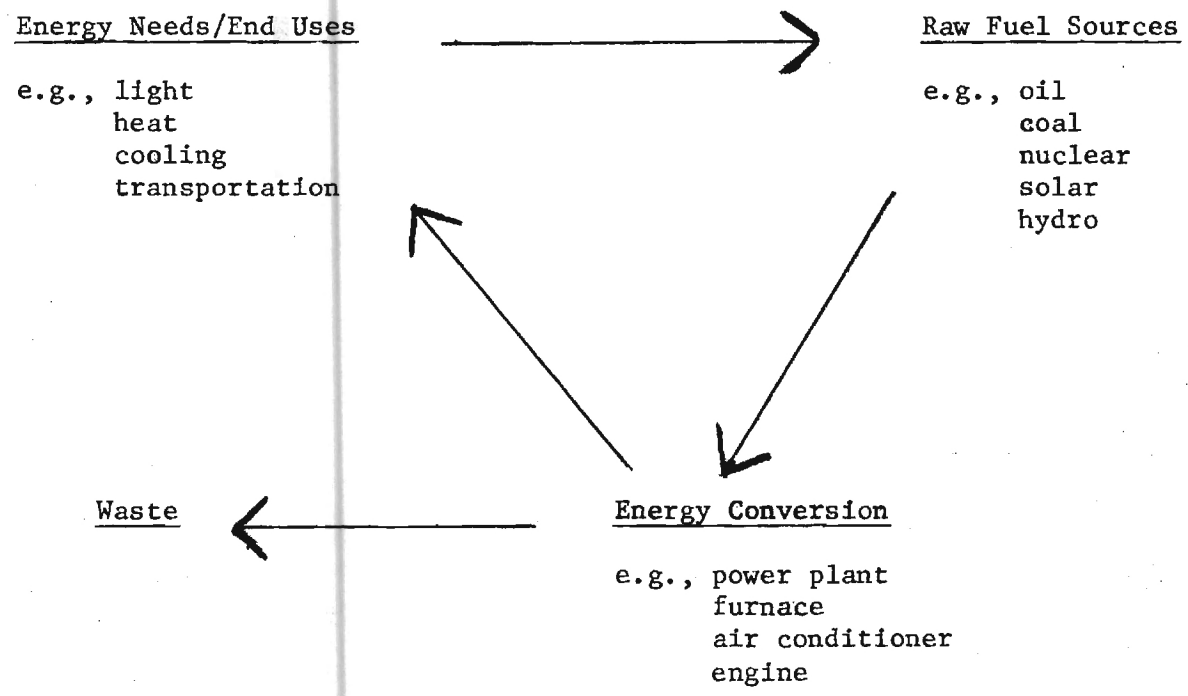
As for the first Outlook, the complex concept of conservation -- which includes both doing without and using more efficient means for the same outcome -- receives short shrift in the NRC/NAS chapter. Other notable omissions include the NSF commissioning (or, at least, the publication) of no paper on energy per se. Fortunately, the Department of Energy statement attempts to link various energy alternatives (i.e., goals) to strategies for their attainment; the five-year time frame, as elsewhere, goes generally unheeded.

Finally, the interdependence of energy, environment, materials, and health -- as dramatized by the Three Mile Island accident -- must be acknowledged (in this regard, see Morgan's review of NRC/NAS chapters 5 and 9 in Appendix C, and the NSF-commissioned paper by Seskin and Lave). Energy will remain a central topic of policy concern. It will behoove future Outlooks to treat it as such.

3. Environment. This topic is another one fraught with controversy. Much of the controversy turns on the question, "What is 'acceptable risk'?" The Seskin-Lave paper, and similar efforts (e.g., Lave and Seskin, 1979), is exemplary of a humanistic approach to cost-benefit analysis. Too often, human life is discussed in purely economic terms. One corollary approach is ALARA (As Low As Reasonably Achievable) formulas, e.g., \$1,000 per person rem, for expenses incurred in the reduction of hazards. What price human life, e.g., in the workplace? And how do we calculate corporate responsibility for it?

Perhaps the chief observation made in the NRC/NAS chapter on toxic substances in the environment is that growing awareness of chemical hazards -- many created by technological advances -- is a first step toward control and reduction of those hazards by S/T means (p. 463). Thus, the need for public

Figure 1
ENERGY FLOW IN THE U.S.



source: Adapted from lecture by Prof. Sam Shelton, April 1980

understanding, including the development of risk assessment techniques, is recognized. Nelkin's NSF-commissioned paper takes this recognition a step further by examining various modes of public participation in such assessments. She is to be lauded for directly confronting the problems entailed by the politicization of technical controversies.

It is on social problems and processes of regulation that the NRC/NAS chapter falters. For while the Delany Clause and the Occupational Safety and Health Administration Act are mentioned, the role of epidemiology and toxicology is largely overlooked. Their importance lies in detecting toxic agents such as non-thermal ionizing radiation (alluded to in the HEW/Alcohol, Drug Abuse, and Mental Health Administration statement), and translating their data into guidelines for legislating definitions of toxicity that are consistent across regulatory agencies, and therefore, enforceable. For example, the clearinghouse function of the National Toxicology Program created in 1978 is mentioned only in the HEW/National Institutes of Health statement of the Outlook.

The twin themes of educating the public to environmental hazards and, at the same time, improving our screening techniques (which the NSF overview admirably features) should be accompanied by forthright admission of regulatory and waste disposal mistakes. This will begin to unshackle industry from "fuzzy" and contradictory controls and raise government credibility among consumers and industry alike. In the wake of the Love Canal tragedy, such an admission in future Outlooks would be a modest step toward rectification and enhanced accountability to the public. Such a tone is noticeably absent, at least from the NRC/NAS chapter. This is remedied in part by the two Department of Interior statements and, less so, in that by the Nuclear Regulatory Commission.

4. Health. That the topic of health has already been touched upon attests to its interrelation with other issues addressed in the Outlook.

Among the aspects of its treatment by NRC/NAS (fully reviewed in the Bowden-Rhodes paper; see Appendix D), the following are prominent:

- a. A formidable "laundry list" of health issues is introduced, in language and format that fluctuates wildly in level of technical sophistication and in time frame.
- b. The section on special social, psychological, and medical problems of the elderly is commendable.
- c. A general lack of attention to health care delivery, the gap between theory and practice, and the historical tension between politics (e.g., professionalization and specialization of medicine) and chronic dread diseases (see Strickland, 1972) is evident.

The prevalence of a "medical model" bias in the Outlook leads predictably to an endorsement for more research as a solution to health problems. Emphasis on a "behavioral/social" model would portray health problems more in terms of access to services and difficulties in measuring health status (see Kay's outline in Appendix C). If health problems are modeled in the latter way, the maldistribution of physicians, treatment, and care emerge; the economic correlates of such maldistribution are equally clear (as Warner's NSF-commissioned economic analysis demonstrates). Finally, while concern for the 1-2 "killer" diseases, heart and cancer, is defensible, review of diabetes is certainly not. With all the resources at the behest of NRC/NAS, any Outlook should contain a cutting-edge perspective on the conversion of biomedical research into foreseeable palliatives and cures. (Admittedly, recombinant DNA technology -- which will result eventually in, among other things, a synthesized insulin gene -- is covered in the chapter entitled "The Living State" and noted in two agency statements. Nonetheless, some recombination of chapters seems to be in order.)

5. Communication/Computers. This topic received a glut of attention in the Outlook. Of the NRC/NAS chapter and the three NSF-commissioned papers, only one of the latter (Rule's on privacy) ever questioned the need for information. Yet, little in the way of information technology -- what is its etiology, what is driving it? -- is presented. The impression is that after transistors, everything happened, and that the technology is advancing as a series of refinements of the silicon chip. The prediction that one megabyte chips would appear in the U.S. by mid-1980 has been "anticipated" by announcements in Science this past Spring that the chip has been developed in Japan.

Of course, computational capacity has increased. This underscores the hardware-software gap, i.e., the limited development of the latter due to predominant investment in the former. The outlook presented by the NRC/NAS chapter is simply that more computing by more people is expected, and an endorsement of micro- and mini-computers.

The commissioned papers are more analytical and critical of communications, and especially of the uses of computerized information in American society. From legal (Belair), sociological (Rule), and economic (Dunn) perspectives, several questions of access to markets for, and regulation of, information systems are raised. Thus, the policy issues signalled by the Privacy Act of 1974 and the Freedom of Information Act are dealt with in only one component of the Outlook.

The agency statements (e.g., by the Commerce or Defense Departments) fail to indicate where trends in communications are apt to change as a result of R&D activity. Here, too, it strikes us that the omission of regulatory agencies such as the FCC and the FTC precludes many insights into policy that are relevant to a short-term outlook. Likewise, to exclude the private sector from offering a perspective(s) on federal R&D policy and regulation seems shortsighted. Certainly the stake of IBM and other multinational corporations in information technology warrants inclusion.

6. Academic Science/Graduate Education. Treatment of this topic by NRC/NAS may suffer from a surfeit of data, presented in graphic and tabular forms that are insufficiently discussed in the text of chapter 10. The value of graduate education is assumed in this chapter (p. 469). However, in the present context of shrinking resources, such an assumption should be openly discussed. Since the linkage between academic science and graduate education is made in the title of the chapter, a more explicit science manpower orientation can be expected; it never materializes. The enrollment figures presented for undergraduate and graduate education are not accompanied by an explanation of "birth control" measuring, attrition, change in the MA/MS-Ph.D. student ratio. Utilization of demographic data collected by the NRC Commission on Human Resources and reported in their annual U.S. Ph.D. recipient profiles and numerous other reports are disappointing.

This is the shortest chapter in the NRC/NAS volume. Given the brevity, we hasten to point out three issues which should be explored in future treatments of academic science. One is establishment of academic-industrial relationships, e.g., Harvard-Monsanto, and the certain increase in collaborations between pharmaceutical companies and medical school research scientists for the genetic engineering and marketing of "replacement" substances, organs, etc. A second issue which is cited (p. 488) in passing concerns the problems of the federal research bureaucracy that has spawned a "counter-bureaucracy" in the university. Efficiency and accountability have declined in the process. Finally, the issue of the public's science literacy needs to be considered in the context of undergraduate instruction and novel forms of education. What kinds of programs can be implemented to cope with this need, one which appears to parallel the urgency of our pre-Sputnik lag behind other developed nations?

Training of a knowledge elite (underemployed, at that) should not occur in lieu of mass education, for reasons of public confidence and participation in technical decision-making that Nelkin, Kranzberg, and others explain in their NSF-commissioned papers. This is the essence, we would argue, of a democratic society. Related to this need is the transformation of basic research into applied innovations (see Brooks, 1978; Kelly, et al., 1978), and the role of interdisciplinary degree programs for training experts to cope with pressing societal problems created by or in response to S/T innovations.

7. International Cooperation. This final topic is indicative of the imbalances in treatment that pervade the first Outlook. The NRC/NAS chapter avoids discussion of the politicization of science and technology in any form. Institutional and ideological barriers to cooperation are barely acknowledged. The potential buffer role of international scientific unions and national academies -- in negotiating technology/information transfer and human rights disputes -- remains unexplored. It is not that this chapter, or the statement by the Department of State for that matter, is not informative; rather, it lacks a policy orientation which admits, first, of the tensions in the world, and second, of the impacts these tensions have on scientific and technological undertakings.

A comparative perspective on how other nations have dealt internally with common problems in the First, Second, and Third Worlds would contribute to an international perspective on such problems. To exempt from scrutiny most of the controversies and challenges inherent in international affairs, e.g., terrorism and arms proliferation, is to express pessimism about the ability of institutions to ameliorate such controversies and challenges. We doubt this is the impression either the National Academy of Sciences or the National Science Foundation wishes to convey.

III. Recommendations for Future Outlooks

Since the foregoing evaluations have been unsparing in criticizing the first Outlook, it is incumbent on us now to propose an alternative for the second and subsequent Outlooks. Without repeating topic-specific suggestions for improvement, we will emphasize ways to reformulate the Outlook to enhance its utility as a policy document. Our recommendations can be subsumed under two headings: scope and format, utilization and impact.

A. Scope and Format.

In the words of the NSF Director, Richard Atkinson, the object of the first Outlook "was to capture perspectives, not to produce a catalogue" (NSF overview, p. 3). We could not agree more; therefore, our quarrel is not with topical choice, but topical presentation. As part of the strategic planning for S/T, the Outlook reflects how, in the words of Daniel Bell, "the United States is passing into a post-industrial phase in which theoretical knowledge is a strategic resource and science policy determines political action" (1976, p. 46). Efforts to direct S/T and assess those efforts mark the transition to a new era. The first Outlook points to that transition, invoking Vannevar Bush's Science, The Endless Frontier as a transition benchmark. Future Outlooks must anticipate the problems of a new era.

Hence, a problem -- instead of a discipline -- orientation must be employed. The Outlook's scope need not be enlarged. rather, treatment of selected problems must seek a broader, yet distilled, range of perspectives that a policy-maker and an educated lay person can comprehend to use for planning and persuasion purposes. The Outlook must both synthesize and document a diversity of interpretations and predictions. If it is to have any effect on the policy-making process, it must command an audience. Its format is the key to such command.

At the outset of our seminar, it was observed that the legislative timetable corresponds to the period covered by the first Outlook; it was further noted, however, that the scientists' timetable, e.g., for discovery, is essentially open-ended. Yet we are asked to contribute to the "early warning" system which the Outlook represents. The NRC took eight months (August, 1978 - March, 1979) to report on "the current state of significant research areas and...those areas that could be of special concern with the five-year period" (1979: XIV). The intent of NRC was consistent with, albeit narrower than, the legislation of 1976; its execution was less satisfying to us than any other component of the Outlook due to its textbook-ish, basic science, research-is-the-panacea orientation. The entire Section "I. Science" is explicitly in this genre. We urge no repetition of these chapters.

Likewise, soliciting agency statements affords the respondents an opportunity to justify their current finding priorities; commitments to future priorities are unlikely to be stated. Rather, a rehearsal of problems is apt to appear. That is what we got. And commissioning independent scholars is again well-conceived, but reformatting their work is essential if such "support" documents are to engage policy-makers.

Our proposed reformatting would feature standardized presentations. But the set of topics treated in each Outlook would change from biennial volume to volume. Every topic would consist of a problem, its definition, a characterization of the S/T issues encompassed by it, a statement of policy options for dealing with the problem and its component issues, and a corresponding set of anticipated consequences or scenarios (see Pearson, et al., 1978) for each alternative discussed. Such a format would preserve the apolitical status of the Outlook, while addressing the real-world context and content of the problem. It would try to link that state of knowledge with specific needs and the role of legislation, the courts, and the public in resolution of the

problem.

It is our preference, too, that all the components relating to a problem appear together in a section; thus, in sequence, the perspectives of the various relevant stakeholders can be scrutinized. These might include the NRC/NAS, federal R&D and regulatory agencies, representatives of the private sector (business and industry), and something akin to NSF-commissioned papers. Commissioning short, well-delineated analyses that would be synthesized by a commissioned editor would obviate the redundancy that plagued certain topics in the first Outlook and the lacunae that were equally conspicuous. An extensive index that lists topics and issues would cross-reference themes that appear in more than one section.

Because our topical compilation format would be lengthy, we envision two separate volumes for future Outlooks. The first volume would be an accessible overview/executive summary (ca. 50 typewritten pages) of the contents, particularly the policy options and scenarios contained in the second volume. This latter volume would be a reference guide for the reader interested in probing specific problems and issues. The former would "hook" the primary audience -- legislators, other policy-makers, and concerned members of the public.

B. Utilization and Impact.

With the exercise of greater care in selecting problems and defining them for prospective analysis, a streamlining of the Outlook should occur. Instead of textbook coverage by whole disciplines, current problems will be reviewed in depth. Chronic diseases, for example, need not be covered in every biennial Outlook. A schedule of topics should be generated to assure timely coverage, and updating in subsequent Outlooks. Part of such coverage should be a recent legislative history that relates new knowledge to new applications, and eventually, measurement of change in the problem site.

The National Science Board's Science Indicators series is exemplary in this regard. Almost a continuous monitoring of trends in the health of U.S. S/T is paralleled by new attempts to measure some aspect of those trends. The cumulative effect is a highly aggregated, but ever more precise, moving picture of S/T progress. (See GAO, 1979, for a critique of SI 76 that prods the architects of the indicators enterprise to even greater precision.)

If the Outlooks are to stimulate dialogue and alteration in federal policies, they must incorporate a strong sense of contentious issues, their respective advocates, and the evidence fortifying their position. Areas of disagreement can be presented "dialectially" (e.g., Mitroff and Chubin, 1979). This mode of presentation includes the diversity of views that must be weighed in making policy choices, ordering priorities, etc. (See the HEW/NIH statement on "consensus development conferences.") Policy-makers must be told not merely that economic and risk assessments are warranted, but also that consensus is lacking over how those assessments are to be conducted and what the resultant findings mean.

As assessors of the first Five-Year Outlook on Science and Technology, the impact of the future Outlooks may be beyond our control. However, it is surely within the purview of our craft to structure our contribution in as complete and unrelentingly critical a way as possible. In our evaluation of this, the first Outlook, we have sought to demonstrate the need for a clear presentation of the "big picture" which, above all, explicitly includes the policy issues inextricably tied to modern science and technology.

IV. Additional Bibliography (Cited in I-III)

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APPENDIX A

Directory of Course Participants
(Georgia Tech, PST 8549, Spring, 1980)

Faculty	School	Topics
Professor Lucio Chiaraviglio	Information and Computer Science	communications/ computers
Professor Helen Grenga	Chemical Engineering	materials
Professor Bonnie Kay	Health Systems	health
Professor Karl Morgan	Nuclear Engineering	energy, environment
Professor Alan Porter	Industrial and Systems Engineering	academic science/ graduate education
Professor Sam Shelton	Mechanical Engineering	energy
Students	Major	Topics
Charles Brown	Physics	materials, international cooperation
Bo Bowden	Management	health, materials
Tom Goddu	Architecture/Industrial Design	environment, academic science
Jason Harry	Engineering Science	energy, communications
Tom Rhodes	Architecture	energy, health
Mary Kay Smith	Management	environment, academic science
George Stephens	Electrical Engineering	communications, international cooperation

PST 8549 Special Problems: The Status and Future of U.S. Science and Technology--A Policy Evaluation M 2-5 P.M., 213 D.M.Smith Professors Chubin, Rossini, and Kranzberg

Spring 1980
Course Schedule

31 March	Overviews:	Chubin, Rossini, and Kranzberg
7 April		Blanpied and Pettit
14 April	Expert Briefings:	Energy and Materials--Shelton/Morgan, Grenga Health and the Environment--Kay, Morgan
21 April		Computers and Communication--Chiaraviglio Academic Science, Graduate Education, and International Cooperation-- Porter/Kranzberg
28 April	Draft Critiques:	Student Presentations on Energy and Materials, Health and the Environment Student Presentations on Computers and Communication, Academic Science, Graduate Education, and International Cooperation
12 May	Discussion:	Agency Statements and Final Report Outline
19 May		Open (to be arranged)
26 May	Discussion:	Draft Final Report
2 June		Critique of the Seminar and Discussion of Future Efforts: Publication Plans, Seminars, and Proposals

APPENDIX C

Sample Faculty Papers

- Energy Policy; Economics of Electrical Utility Investments in Energy Conservation Measure -- Same Y, Shelton
- Review of Science and Technology, Chapter 5 -- Karl Z, Morgan
- Health -- Bonnie Kay

APPENDIX D

Sample Student Critiques

- A General Critique with emphasis on Energy -- Jason D. Harry and Thomas J. Rhodes
- A Critique on the Topic of Health -- Bo Bowden and Thomas Rhodes

ENERGY POLICY

ECONOMICS OF ELECTRIC UTILITY
INVESTMENTS IN ENERGY CONSERVATION
MEASURES

by

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ABSTRACT

The electrical power industry is presently faced with the prospect of ever increasing peakload electrical demand. This increased demand requires continual expansion of generating capacity, an increasingly expensive prospect which must be financed by the consumer through increased electrical rates. In an effort to combat increased home utility bills, several utility-financing utility programs have been initiated across the country to encourage and facilitate the installation of energy conservation measures. If these conservation measures reduce the system peak demand seen by the utility, this frees up existing plant capacity which may be used to meet new load requirements in lieu of building new plant capacity. In an effort to determine the economic impact of this conservative alternative, this study investigates the economic feasibility of utility-financed residential conservation measures versus the present practice of increased generation capacity. The programs studied may involve total or partial funding of residential conservation measures by the electrical utility in lieu of increasing capacity. Criteria are established which will insure equivalent economic benefits for the utility while not penalizing consumers not receiving financing. This insures that all rate payers benefit at no economic penalty to the utility.

It is shown that the utility may subsidize the homeowner for certain energy conservation measures through direct payment or through low (or no) interest financing at no economic penalty to the utility. The resulting impact on all customers is equal or lower rates per kwhr than would result through new power plant construction. In addition, those implementing the

energy conservation measure realize additional savings due to lower
kwhr consumption.

INTRODUCTION

Of the avenues available to us in America to conserve and properly manage our energy resources, we must make a renewed effort to eliminate residential energy waste. Americans spend 1/2 of their time in their homes and it is here that about 20 percent of all energy is used - to run heating and cooling systems, provide lighting and run all manner of electrical appliances. An all electric home in the Atlanta area with 1,600 square feet will average 21,965 Kwh a year with a resultant energy consumption of 250 million BTU's of primary energy at a cost to the homeowner of approximately \$1,000 annually.

The home is at the bottom of the barrel in efficient use of energy in our nation. The transportation and industrial sectors utilize their energy with over twice the efficiency and productivity as the home. Since energy consumed in the home is the closest contact an average citizen can have with this problem, it may be the best place to begin to instill a sense of energy management based upon wise economic decision-making.

If consumers are to conserve energy effectively, they must choose and use their purchases more wisely. They must install more insulation, purchase more efficient appliances, set their heating thermostats lower and their air conditioning thermostats higher. Unfortunately, however, a large fraction of American consumers have a lack of knowledge about the nature of the energy situation and what they as individuals can do to reduce energy consumption in their homes.

In addition, capital for these energy conservation measures is not readily available to the majority of homeowners. Therefore, even when

he does recognize a cost effective energy conservation opportunity, he generally will not make the investment due to lack of capital.

Since the conservation of energy in many cases is less costly than production of that same quantity of energy, the opportunity exists for electric utility companies in Georgia to improve the energy efficiency of homes through a program of home energy audits and the financing of qualified energy-conserving measures to the economic benefit of everyone concerned. In addition, there would be intangible environmental and international political benefits.

Part I of Title II of the National Energy Conservation Policy Act, Pub. L. No. 95-619 requires the establishment of utility programs to encourage and facilitate the installation of energy conservation measures. Under this program, known as the Residential Conservation Service, large gas and electric utilities will be required to provide homeowners with an on-site inspection of the home by a qualified auditor. The auditor will analyze the costs and potential savings of applicable energy conservation measures and provide the homeowner with specific energy conservation recommendations and their economic value.

An additional provision of this legislation allows participating utilities to assist the homeowner in arranging financing for the recommended energy conservation measures. In arranging for financing, utilities may allow customers to repay loans arranged by the utility as a part of the monthly utility bill.

Such a financing program coupled with the RCS audits would then overcome the two major obstacles inhibiting residential conservation measures.

II. ECONOMIC ANALYSIS

The basic problem to be examined is the economic impact of utility-subsidized residential energy conservation measures. The subsidy may be by direct payment or through financing, but that is unimportant to our present discussion. While the suggestion that a power company should pay to, in effect, produce less of its commodity may initially appear ridiculous because of the utility's desire to maximize profits and revenues, a close examination of the general nature of the problem indicates the economic motivation for such a program.

At present the electrical utility industry operates under a restricted enterprise system; profits are carefully controlled by the government to protect the American public, but also to insure the utility a certain reward for production or investment. The fact that the rate of return on an investment is essentially fixed is the primary reason utility-sponsored conservation can succeed.

At present the method of meeting increased peak demands has been to continually increase generating capacity because the utility's rate of return is fixed, when a new investment is made the consumer must pay for the increased capacity through increased electrical rates. It must be noted, however, that due to the nature of the fixed rate of return system, the rate of return is independent of how the capital is used as long as the regulating authority allows it to be included in the rate base. Stated more succinctly, utility profit is determined by amount of productive investment, not purpose. It can be concluded, therefore, that the potential does exist for a utility-financed residential conservation program to be a less costly alternative to new construction. There is the problem,

however, of examining who benefits from, and pays for, such a program.

One would like to develop a criteria to determine when the utility should invest in residential energy conservation measures which causes electrical energy to be used more effectively in the residence. When the utility makes a capital or operating expense expenditure, the effect may be different for different groups. The effect on three different entities need to be examined.

1. Participating rate payer
2. Non-participating rate payer
3. Utility

The participating rate payer is the utility's customer in whose house the utility subsidized energy conservation measure is implemented. The non-participating rate payers are all customers who, by choice or necessity, do not have any utility subsidized energy conservation measures implemented in his house. The utility is the power producing company who is producing the electricity and may subsidize energy conservation measures for their customers.

It is assumed that the utility will be allowed to treat any capital invested in energy conservation the same as that invested in power generating plants and that any interest expense may be charged annually as an allowable expense. Their ROI allowed by the PSC is assumed to be unchanged. This being the case, then the utility profits will be unaffected by energy conservation investments in lieu of power generating plant investments.

The non-participating residential customer will benefit only if the rate per kwhr with the conservation senario is less than it would be with the new plant senario.

The participating customer will receive an additional benefit compared to the non-participating customer due to his reduced kwhr consumption in addition to the lower kwhr cost.

From the above, it is seen that if the conservation program compared to the construction program results in a lower kwhr rate, all customers will benefit and the utilities profits and ROI will not be affected.

The following analysis calculates the maximum dollars which the utility may invest in energy conservation in order to maintain rates per kwhr equal or lower than investment in new power plants. This maximum investment is expressed per kw reduction seen by the utility during their annual peak period due to the energy conservation measure.

III. ECONOMIC CRITERIA

The question of how much the utility company can invest in, or subsidize, energy conservation measures in the home and have the non-participating homeowners benefit from that investment in lieu of new plant construction will now be addressed. Since it is assumed that the utility will be allowed its normal ROI on either capital investment, one would like to know, "What is the maximum amount the utility can invest in energy conservation measures and still maintain a lower rate per kwhr than would result from the utility investing in new power plants?"

The answer is found by writing an equation for the utility's required revenue per kwhr for both cases and setting them equal. The resulting energy conservation investment dollars is the conservation investment which would require the same rate per kwhr for either conservation investment or power plant investment. For this exact case, the utility nor the non-participating homeowner would benefit or be economically penalized. However, the participating homeowner would benefit through his kwhr usage reduction.

Carrying out this analysis, the following results as the maximum investment that should be made by the utility in energy conservation per kw of system peak demand reduction accomplished:

$$C_{EC} = \left[\frac{y + \frac{1}{L_P}}{y + \frac{1}{L_{EC}}} \right] \left[C_N - \frac{F_{EC}}{F_O(1+z)} (C_O + z C_N) \right]$$

where

- C_{EC} dollars invested in conservation measures per kw of annual peak demand reduction seen at the power plant
- C_N dollar cost of new power plant per peak kw of capacity
- C_O dollar assets of existing power plant per kw of capacity
- y before tax return in total assets allowed the utility expressed as a fraction
- L_p power plant lifetime, straight line depreciation assumed to zero
- L_{EC} energy conservation measure lifetime, straight line depreciation assumed to zero
- F_O annual load factor of power plant system without conservation measure; i.e., equivalent fraction of year the power plant system operates at annual peak load
- $$\left(\frac{\text{Annual kwhr produced}}{8760 \text{ hrs} \times \text{Annual Peak kw}} \right)$$
- F_{EC} annual load factor of energy conservation measure; i.e.,
- $$\left(\frac{\text{Annual kwhr Saved}}{8760 \text{ hrs} \times \text{Annual System Peak kw Saved}} \right)$$

z

system annual peak demand growth rate expressed
as a fraction

Taking variable F_{EC} and a reasonable set of values as follows:

$$C_N = \$1,000/\text{kw}$$

$$C_O = \$200/\text{kw}$$

$$y = 0.25$$

$$L_p = 30 \text{ years}$$

$$L_{EC} = 15 \text{ years}$$

$$F_O = 0.5$$

The following table results:

F_{EC}	C_{EC} (\$/kw)
0.0	\$895
0.1	893
0.2	812
0.4	730
0.6	647
0.8	564
1.0	482

This shows that for typical situations, the utility may invest, or subsidize energy conservation measures up to a maximum of \$482 to \$895 per peak kw of reduction depending on the load factor of the conserved electrical energy.

Approximate load factors for several types of electrical loads in a Georgia residence can be calculated with the following results.

	<u>Diversified Peak Demand</u>	<u>Annual kwhr</u>	<u>Load Factor</u>
Space Heating (Resistance)	9 kw	12,000 kwhr	0.15
Space Cooling	3 kw	4,500 kwhr	0.17
Hot Water Heating	0.8 kw	4,500 kwhr	0.64

If an energy conservation measure reduces the space heating load by a fixed percentage, such as insulation, the utility may subsidize this measure to the extent of \$833 per kw of peak demand reduction.

For example, if attic insulation is increased from a typical value in Atlanta of R-11 to R-30 by adding a layer of R-19 insulation, the peak demand of the electric resistance heating system will be reduced by about 0.75 kw per 1000 ft² of attic area. A resistance heating diversity factor of 0.7 has been assumed. The installed cost of the insulation is about 38¢/ft² or \$380 per 1000 ft². The total cost of this energy conservation measure is then \$380/0.75 kw = \$507/kw. We saw previously that the utility could subsidize this 0.15 load factor reduction by \$833/kw, greater than the total cost of \$507/kw.

The estimated economics on this and other energy conservation measures are as follows:

	<u>Approximate Total Cost</u>	<u>Maximum Utility Subsidy</u>
<u>Attic Insulation (R-11 to R-30)</u>		
Resistance Heated Residence	\$ 507/kw	\$833/kw
Electric A/C Residence	1,980/kw	825/kw
<u>Water Heating</u>		
Adding 6" Fiberglass Blanket	\$ 469/kw	\$631/kw
Adding Heat Pump Water Heater	\$1,250/kw	\$631/kw

Subsidy Alternatives

Several subsidy options are available for the utility. The three more obvious are:

1. Cash Payment
2. Low Interest Loans
3. No Interest Loans

Since financing of energy conservation measures is a major obstacle to their implementation. No interest loans with total principle due at the sale of the house is very attractive. The outstanding principle is put into the utility's rate base. Data shows the average house turns over once every seven years.

The present value cost of this type of no interest loan to the utility with a 25 percent before tax ROI is \$790 per \$1000 of principle loaned.

Conclusion

We then see that if the utility made no interest loans, repayable at the time of sale of the residence, for all those conservation items listed in the previous table, the electric rate per kwhr would be less than using that money for new plant. In addition, home owners receiving the loans would reap additional benefits through lower kwhr consumption.

Review of Science and Technology

Chapter 5 - by Karl Z. Morgan

A. GENERAL

1. There is not a shortage of energy but a serious shortage of energy in convenient, more conventional forms and especially a shortage of oil and natural gas.

2. There are difficult but not unsolvable technical and engineering problems in shifting gears to meet future national and foreign energy needs, but the most difficult problems are political, social and economic and the matter of overcoming some of the inertia of our complex society.

3. Society must change some of its perspectives and be willing to modify drastically many of its deeply ingrained ways of life:

(a) Conservation is our greatest, most immediately available and relatively untapped source of energy. EXAMPLES: Turn down thermostats, more insulation, live closer to place of work, use public transportation, recycle iron and aluminum, increase useful life of cars and other machines.

(b) Use More Efficient Systems. EXAMPLES: More MPG for cars, improve efficiency and use of fuel cells and of magneto-hydrodynamic systems for producing electrical energy without going through the usual heat cycle.

(c) Energy Storage Systems. EXAMPLES: Pumped water storage, hydrogen production from water, pressurized cryogenic processing and shipment of natural gas, batteries, heated water and rocks, fly-wheels.

4. Time Displacement between development of new technologies, their public acceptance and the money market to support them, i.e. difficult imbalance. Government can help by

- (a) funding research
- (b) tax incentives
- (c) educating public.

5. Energy Choices.

(a) Near term (to year 2000)

Only coal and nuclear (LWRs) are capable of taking up the slack caused by dwindling supplies of oil and natural gas.

Solar (mostly for water and space heating) and geotherm can make minor contributions.

(b) Long term

Solar in all its forms. Nuclear - Fission reactors with fuel reprocessing and breeders. Nuclear fusion - probably no contribution before year 2050.

B. SOLAR ENERGY

1. Biomass: energy from domestic and industrial waste, energy farms (e.g. sorghum and sugar cane) for production of alcohol, tree farms, algae farms. Promising.

2. Wind: use of efficient wind foils. }

3. Hydroelectric: more small systems. }

4. Ocean and lake thermal gradients. }

Promising in special and limited areas of U.S.

5. Ocean wave action.

6. Direct Conversion.

(a) Flat plate collector for water and space heating are very promising, relatively inexpensive.

(b) Photovoltaic - crystalline and amorphous materials, promising as supplementary source of electricity for homes. Requires more development to reduce cost and efficiency. Problem of maintaining clean surfaces of collectors. Requires hundreds of acres for collectors needed by a small central power station.

C. NUCLEAR

1. Fission Reactors.

At present time 71 are in commercial operation supplying 13% of electricity in use in 1980 in the U.S. In addition, there are 118 nuclear power plants in various stages of construction with start-up dates scheduled to 1991 or a total of 189 nuclear power units. Of these 189 nuclear power units over half are pressurized water reactors (127 PWRs) and most of the rest are boiling water reactors (59 BWRs). There is one liquid metal fast breeder reactor, LMFBR (Clinch River breeder reactor), one high temperature gas cooled reactor (HTGR) and one light water graphite moderated reactor (LGR). Most of the present nuclear power plants are operating at less than 1000 MWe (50-1100 MWe) though most of those under construction will operate at about 1000 MWe (900-1200 MWe). The PWRs and BWRs are referred to as light water reactors (LWRs). Unlike Canada's CANDU reactors which operate with natural uranium (nature's mixture of 99.276% ^{238}U + 0.7196% ^{235}U + 0.0057% ^{234}U), our LWRs require the very expensive enrichment of ^{235}U to about 3%. In addition, only about 0.6% of the energy potentially available in the uranium is available for use in the LWRs. The U_3O_8 reserves in the U.S. amount only to about 700,000 tons (even the estimated resources are only about 3.6×10^6 tons) so with the present wasteful LWRs we have only a short term energy source. For example, if all our present energy of about

75 quads/y were furnished by LWRs, the reserves would be depleted in less than 20 years. The only long range future for nuclear power is to convert from our present LWRs to breeder reactors or a combination of breeders and convertors [Note: a breeder produces more fissile material ($^{239}\text{Pu} + ^{241}\text{Pu}$ in case of U-based reactors and ^{233}U in the case of thorium-based reactors) than it consumes in producing heat, the convertor produces about as much fissile materials as it consumes while the LWR produces very much less].

Breeder programs in the U.S. have been on a stop-go basis during the Carter Administration, i.e. Carter tries to kill the CRBR-LMFBR while Congress gives it a few hundred million dollars each year to keep it gasping for survival. This writer sides with Carter on this issue. I am for breeders and for a long range future of nuclear energy, but have strong opinions which can be summarized as follows:

1. We have made and in some cases continue to make serious mistakes in our LWR program which must be corrected. The industry cannot afford many Three Mile Island accidents.
2. The LMFBR was a bad mistake. For years we put all our eggs (billions of dollars) in this one basket. The French, Russians, British, Japanese and West Germans have had superficial success in their LMFBR programs, but the climate will change when present research shows other breeder systems are a much better choice.
3. The LMFBR operates on tons of plutonium, one of the most hazardous materials presently known.
4. The Pu in unirradiated (fresh) power reactor fuel can be manufactured very easily by surreptitious or clandestine operations to produce low grade but very powerful nuclear weapons. Hijacking

operations could result in blackmail and/or destruction of major cities or start of World War III (maybe the Last World War).

5. Breeders can be operated on the Th-cycle where essentially no Pu would be produced.

6. The ^{233}U can be denatured with ^{238}U so that it could not be used to produce nuclear weapons. Even more important, it always contains ^{232}U and ^{234}U which produce daughter products with high γ -ray yield such that its manufacture into weapons would be very difficult and expensive.

7. Spent fuel reprocessing plants for breeders and convertors should be in carefully selected, isolated places and operated under international control. Here the primary breeders could operate on U with a Th blanket to produce denatured U for outlying converter reactors.

8. Other breeders than the LMFBR can be made much safer, more economical, more proliferation proof and made to meet the world's energy demands for thousands of years because now the cost of power would be so low that very low grade U supplies as well as Th-supplies would be used. Perhaps this cheap energy could now be used to extract U and Th (along with other minerals) from sea water while adding to our much needed fresh water and hydrogen gas supplies (as a substitute for our depleting supply of natural gas).

2. Fusion Reactors.

Fusion reactors would release energy from the excess mass ($E = m \times 9 \times 10^{20}$ ergs) when light elements (e.g. ^2H , ^3H , ^6Li , ^7Li) are combined to form heavier elements (especially ^3He and ^4He). Much work and billions of dollars have been spent on the development of fusion.

Some difficult but no known insoluble problems lie in the way of success of this program. Of the three competing types of fusion reactors - tokamak, magnetic mirrors and droplet implosion by laser beams - tokamak is leading the race at present. It seems unlikely the first commercial plant can go into operation before the year 2050. This will be a great day because then the oceans can furnish our fuel (^6Li , ^7Li and ^2H).

D. COAL, OIL AND GAS

Coal is a valuable chemical, too valuable to burn. The sooner we use it to make drugs, food, paints, plastics, fabrics, etc., instead of burning it, the less future generations will curse us for wasting this vast but limited God given natural resource.

1. Direct Use of Coal in Power Plants.

The present coal reserves in the U.S. are probably about 500 billion tons (4000-5000 quads) and the resources may be greater by a factor of 10; however, much of the resources would be low grade coal. With a 2%/y energy growth (compared with 2.5%/y between 1920 and 1972) the coal reserves of the U.S. would be exhausted in one century assuming coal accounts for almost all energy growth in this period.

At the present moment the future of nuclear power is rather uncertain and the principal emphasis of our government seems to accelerate the direct and indirect (synthetic oil and gas) uses of coal. This imposes serious impending problems of environmental pollution, fresh water shortage, landscape defacement and abuse and the greenhouse effect.

Natural oil and gas are mentioned here only as a rapidly depleting energy source. This is very serious because the immediate and short range shortage is not shortage of electricity or even of available electrical energy, but a shortage of liquid and gaseous fuels to which

our present economy is finely tuned and treacherously dependent. The present recoverable oil in the U.S. represents little more than a 15 year supply or 32 years at the present (1980) import rate. The recoverable natural gas in the U.S. is estimated at about 5×10^{14} cubic feet per year, this is hardly enough for 25 years. There are, however, some prospects of importing large amounts of gas from Mexico and Canada and perhaps discover new sources from deep drillings in the U.S. and our continental shelf. Shipping of liquidfied gas is less promising because of the hazards and expense. However, liquidfied gas is an attractive substitute for automobile fuel if the price of gasoline continues to rise.

2. Indirect Use of Coal

The use of coal in the production of synthetic gas and oil is a direction the U.S. is bound to move both in the short and the long range unless some very innovative developments take place such as the development of a light-weight, cheap and efficient battery for the operation of automobiles. The cheaper synthetic gases would be less efficient (fewer BTU/g) than those gases more expensive to produce.

E. OTHER ENERGY SOURCES BESIDES NUCLEAR AND COAL

Other energy sources with the exception of Solar probably will never make more than a minor contribution to the U.S. energy needs. There will of course be some local communities where wind power and geotherm will make important contribution and in special locations ocean gradients, small hydroelectric plants and wave power will be of significance, but the effective and efficient use of these sources depends critically on the development of better energy storage systems or they must be tied in to a large electric power grid operating on coal or nuclear and perhaps

operating on synthetic gas and liquid fuels made from coal. Since one attractive method of storage of energy is in the form of hydrogen separated from water by electrical energy, it may be that during the early part of the next century large remotely located nuclear power plants will store energy during off peak load periods in the form of hydrogen gas.

Much is said about the importance of cogeneration of energy in the future and hydrogen gas appears to me to be an ideal choice of fuel for such plants operated in densely populated areas.

F. RISKS AND HAZARDS IN THE PRODUCTION AND USE OF VARIOUS FORMS OF ENERGY

There are few things we get for nothing and energy in the forms demanded by society is no exception.

1. Damage to Man's Environment or to His Ecosystem.

All forms of energy conversion exact a price in terms of damage to man and his environment. In most cases man appears to be one of the most sensitive elements in the environment, but this does not necessarily follow in every case. For example, the lethal radiation dose of some pine trees is less than that for man and many plants, insects and birds seem to be more sensitive to damage from atmospheric chemical pollutants than is man.

Although the large scale use of solar energy may at first sight seem to have few if any of the noxious associated features of other energy sources, it is by no means free of harmful effects on man and on his environment. Direct conversion of solar energy for home water and space heating presents very few environmental problems other than the usual ones in association with the manufacture of the collectors and associated

equipment. Solar collectors for the large scale production of electricity, however, would require the use of thousands of square miles for spacing the collector mirrors and other equipment. This would displace land which competes for other important uses such as farming, forests and the habitat of many living organisms.

Indirect use of solar energy may be equally damaging to the environment. For example, conversion of large areas of farm land to production of sorghum and sugar cane to make alcohol could seriously lessen the supply of grain and other food crops. Windmills might be a serious hazard to migratory birds and ocean gradient or ocean wave power plants could seriously disturb the marine life.

The damage of nuclear power programs to the environment begins at the mines and ends only with the final disposal of radioactive waste and decommissioning of the plants. The open mines deface the landscape while the slag piles and holding ponds release radioisotopes ($^{220,222}\text{Rn}$, $^{228,226}\text{Ra}$, ^{210}Po , etc.) to the environment as well as many harmful chemicals. In case of accidents at nuclear power plants or reprocessing plants large amounts of radiative material could be released to the environment where they could be harmful to the entire ecosystem. The risk of major reactor accidents is very small, but probably at least a factor of 10 greater than suggested by the Rasmussen report.

Coal and oil and to a lesser extent natural gas burning in power plants result in widespread environmental pollution. Coal burning plants produce SO_x , NO_x , hydrocarbons, CO and CO_2 , particulates and metallic pollutants (e.g. As, Hg, Pb) and these take an enormous toll in terms of environmental damage.

The pH has dropped to 5 or less in about 1/6 of the U.S. and to less than 4 in many wide areas. These chemical pollutants damage the field crops, pasture lands and forests and bring to the point of near extinction many living organisms that are fighting a losing battle for their survival. Improved methods of burning coal (fluidized bed, scrubbing of exhaust gases, various means of increasing alkalinity, e.g. use of limestone) are reducing these atmospheric pollutants, but considering the increasing costs of energy and the future use of poorer grades of coal, there is need for much new and innovative research. One of the most serious environmental pollutants by power plants is thermal energy. About 60% of the thermal energy from coal fired modern plants is dumped to water and air environments and about 70% from nuclear plants which in general operate at lower temperatures. There is room here for research on higher temperature systems (with less NO_x production), the use of topping cycles, improvement in magneto-hydrodynamic systems of conversion to electrical energy, etc.

One of the serious environmental problems resulting from large increase in burning of coal for power production and wood to clear forests in tropical regions, e.g. along the Amazon, is the rapid increase of CO_2 in the troposphere. The CO_2 permits the shorter wave lengths of solar radiation to reach the earth but traps the reflected radiation of heat (infra red). Thus, the temperature of the earth slowly rises and in less than 100 years we can expect sufficient increase in the earth's surface temperature to adversely effect the earth's climate. Because of the inertia of our society, this could result in untold loss of dollars and lives in the centuries ahead and over 1000's of years the flooding of major cities.

One of the greatest insults to the environment over the long range from the production of electricity is the consumption of our limited fresh water resources which are needed for other things. This, together with the thermal problem, has resulted in location of power plants in coastal areas, use of man-made lakes, use of dry and wet cooling towers, etc. The production of synthetic gas and liquid fuels faces a serious problem of water supply because in the coal-rich areas water is already in short supply. Also, in many cases there is the question of how best to dispose of large quantities of contaminated water.

Geotherm has its environmental problems of contaminated water and high levels of $^{220,222}\text{Rn}$ and S in the gas emissions.

2. Damage to Man.

Most probably the use of coal in power plants presents the greatest direct hazards to man. The SO_x and NO_x in combination with the released particulates from a coal fired plant lead to an increase of many respiratory diseases (chronic bronchitis, emphysema, asthma, etc.) and some of the pollutants -- especially certain of the hydrocarbons are known carcinogens and mutagens. Some seem even to be implicated as one cause of heart disease (the major cause of death in the U.S.). The thermal pollution of water destroys the habitat of certain types of fish and other marine life and in general seems to increase some of the less choice seafoods at the expense of choice ones. Both nuclear and coal burning plants produce radioactive pollutants in the environment. In the case of the LWRs the radioactive noble gases and tritium (^3H) are released in large quantities, sometimes reaching thousands of curies per year from a 1000 MWe plant. In many cases the environmental exposure from the Ra, Th, Po, Rn radionuclides in the discharged gases

from a coal fired plant results in a higher dose than that from a nuclear plant of the same electrical output.

In considering human damage from a power plant one must consider the entire fuel cycle in each case. For example there have already been over 200 deaths among underground uranium miners from lung carcinoma, most of which was caused by inhalation of daughter products of ^{222}Rn . Also all the risks of mining, refining, enriching, fabricating, shipping, waste disposal from uranium operations must be considered as well as the risks directly associated with the nuclear power plant. The same is true of the coal fired plants. The black lung hazard is very real and shipping of thousands of tons of coal results in many accidents.

The hazards from the transmission of electrical energy are known to exist, but are poorly understood. These hazards increase rapidly as the line voltage on open transmission lines is increased in order to reduce the line power losses. Both the electric and magnetic component of the 60 Hz radiation contribute to this damage in man.

Accidents and careless practices at the processing-fabrication plant near Denver, Colorado has resulted in a serious problem of environmental pollution by Pu and other transuranic radionuclides and preliminary surveys suggest this has caused considerable human damage; in any case it is resulting in multimillion dollar lawsuits now in progress.

The psychological damage from living under the plume from the stack of a coal fired plant or near the Three Mile Island plant is difficult to evaluate, but is real and most important. The risk of radiation induced lethal cancer is about 6×10^{-4} cancer per person-rem. Some studies strongly suggest that there are synergistic effects

resulting from concurrent human insults. For example studies of Bross indicate the risk of cancer increases only about 50% if a child received in utero exposure, but it increases to 5000% if also the child developed certain respiratory diseases in early childhood. Similarly SO_2 may be relatively harmless to man unless particulates are present also in the air.

In the future the handwriting on the wall indicates there will be a large increase in production and use of electricity. Much has been said about the advantages of cogeneration. However, in order to use the low grade heat in heating hot water and homes or in industries that normally gravitate toward the labor supply of cities, the power plants would have to be built in or very near the cities. This, of course, is exactly what we try to avoid in terms of radiation and chemical pollution in man's environment. In fact since Three Mile Island the trend seems to be to seek the building of nuclear plants in far more isolated areas. Perhaps certain industries that can use low grade heat would advisedly gravitate close to isolated power plants (both nuclear and coal burners). Probably the best hope for cogeneration is for hydrogen burning plants to be located in the centers of large populations. Also, some studies have shown promise for the development and use of very small hydrogen powered plants to produce electric energy in homes and schools where both electric and heat energy would be consumed locally while producing potable water as the byproduct.

Because of the present political climate following the Three Mile Island accident and the increasing costs of new reactors and the tightening restraints on their operation, the future of nuclear power in the U.S. is uncertain. Ten new orders for units once planned to begin operating between 1986 and 1990 were canceled in 1979 and no new

orders for nuclear plants were placed by U.S. utilities in 1979; only one plant received a construction permit.

On the optimistic side, with the expected resumption of NRC licensing by Spring of 1980, ten more plants with a combined capacity of over 10,000 MWe will be in operation. If all the 118 plants under various stages of construction or on order come on line as scheduled, over 180,000 MWe will be on supply in the mid-90s by the nuclear industry.

Overview -

1) Characteristics of practice of medicine have changed greatly since 1900

Flexner Report

phase out of apprenticeship system

hospitals - increasing shift to inpatient care - relationship of doctors

role of AMA in determining practice characteristics

2) Health status patterns of U.S. population have changed greatly since 1900

infectious - - chronic diseases

role of non-medical factors - sanitation, water quality, work environment

immunization

chemical (pharmaceutical) intervention

some question as to actual effectiveness

e.g. antibiotics taking credit for large drop in acute illness incidence - - for example, T.B.

1812 (NYC) mortality 700/100,000

1882 - Koch isolates/cultures bacillus, 370/100,000

1910 - 1st TB sanatorium open, 180/100,000

After WWII but before antibiotics became routine, 48/100,000

3) Measuring health status

infant mortality rate as an indicator

U.S. is higher than Sweden, Netherlands, France, Switzerland and Japan for white infants; is higher than 9 countries for all infants;

indicator might be misleading;

impact of chronic illness requires indicator sensitive to the quality of additional years of life

4) Problems (i.e. not emphasized in text)

best treatment available within system not an indicator of quality of system as a whole

shortage of primary care

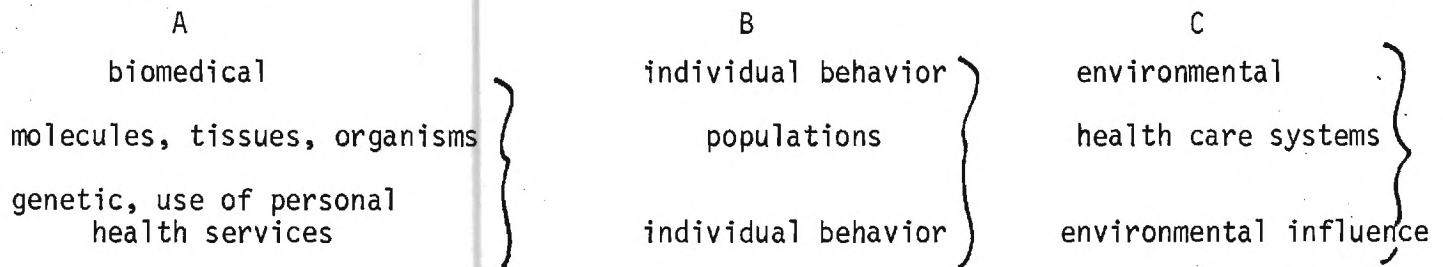
focus on acute care - - lack of preventive programs emphasis

harmful side effects from treatments

maldistribution of physicians & resources in general
fragmentation & episodic care; myth of "choice";

Comments -

- 1) while levels of influence on health are recognized, exists overwhelming emphasis on A



- 2) narrow interpretation of "technology" -

- 3) structure:

draft paper: selected basic research trends - 6 pages
 environmental considerations - 2 1/2 pages
 health care delivery - 1/2 page
 resource allocation - 1 page

S & T : cardiovascular diseases - 9 pages
 cancer & related problems - 5 pages
 cigarettes & health - 3 pages
 mental health & behavioral sciences - 7 pages
 aging and health - 5 1/2 pages
 genetic factors - 1/3 page
 innovations in HC delivery - 5 1/3 pages
 perspectives on health - 6 pages

- 4) lack of mention of political constraints to innovation and research

- 5) no mention of role of operations research in health care delivery

enormous gap between theory & practice at present;

A FIVE YEAR OUTLOOK

A General Critique
with emphasis on
ENERGY

Jason D. Harry
Thomas J. Rhodes

5/26/80

OUTLINE

I. GENERAL COMMENTS

- a discussion of the purpose, expressed and supposed, of the enabling legislation.
- observations of the relative success and failures of the submitted documents.

II. THE ENERGY DOCUMENTS

- a closer look at those documents intended to explain where we are and where we are headed in the energy situation.

III. A FORWARD LOOK

- suggestions for next time.

I. GENERAL COMMENTS

The very fact that the U. S. Congress has recognized a need for professional and expert input into decisions being made regarding science and technology policies is perhaps the most positive aspect of this entire endeavor. The issues surrounding these decisions are incredibly complex. Bodies of knowledge once thought to be independent and exclusive - physics, morality, biology, ethics, and others - are, it now seems, entangled in a most unsettling way. Having realized that they cannot "go at it alone," Congress has done everyone, not just themselves, a favor by demanding outside assistance.

True to governmental form, approximately one thousand (1000) pages of material will be delivered in response to Congress' request. Magnitude notwithstanding, the question must still be asked, "Does it fulfill the need?" This question would be more easily answered if a clearer definition of the need had been made by those who requested assistance initially. Should the writers have concerned themselves strictly with explanations of the various sciences and technologies and the directions they are heading or would it have been more helpful if the orientations had been toward outlining objectively the conflicting issues? This lack of definition has caused a sort of randomness in these documents. Even

allowing for its being the work of many different authors, the material lacks cohesion and "singleness of purpose."

Another central issue regarding the manner in which these documents were requested is that of time frame. More specifically, is five years a reasonable and worthwhile perspective in which to discuss science and technology? We feel the answer to be a qualified "no." The author of the Introduction to the NSF Volume I noted that, "most technological innovations that are likely to be available in five years are already, today, in an advanced stage of development." (Pg. 45, NSF Vol. I) Thus, from an informational standpoint, there is little that Congress could do to promote the development or deployment of technologies intended for the next five years. (They could, of course, inhibit either.) The author further states that, "Decisions about priorities for science and technology made during the next five years, however, can and will have measurable effects in the period beyond the next five years." (Pg. 46 NSF Vol. I) Given the statement on Pg. 45 and that decisions made in the near future set the stage for the coming decades, it seems clear that the outlook has little to do with five years and that calling it a "Five Year Outlook" has only compounded the problems of those trying to write and evaluate it. A cogent and helpful description

of the relevant time perspective difficulties can be found in the "Energy" chapter of the NAS Volume. (Pg. 254-6) Here, after having given some justification, the authors dispose of the implied five year constraint and unabashedly offer tables pertaining to the year 2010 for our perusal. (Pgs. 258-9 NAS)

There are two broad categories of discussion that are conspicuously absent from these documents. The first is the private sector. Much of science and technology development, etc., is carried out with private talent and funds, and this segment of our society certainly could offer valuable comments. The second absentee could be termed "etiology of the state-of-the-situation." More specifically, critical observations of what the government (and others with power) have done right and wrong in order to affect our current "state-of-situation" should be made.

II. THE ENERGY DOCUMENTS

The very vastness of the topic of energy forces us to question whether or not it can be discussed in any adequate manner in the space allotted. Perhaps a division of labor within this area or alternative condensed topics should be suggested. Efforts to include everything in 50 pages has, in the NAS volume, produced a chapter that

lacks coherency. For example, we are told on the first page of the chapter (Pg. 253) that "the principal alternatives are coal and nuclear fission," and "find out" much later that, "Coal is by far the most destructive fuel in ecological and public health terms . . ." (Pg. 273) and that nuclear accidents, "could be catastrophic indeed," (Pg. 271). The verity of the statements notwithstanding, the format for presentation is cumbersome. The format used in the agency statement of the Department of Energy (DOE) is somewhat easier to follow. The various energy alternatives are treated separately and completely covering political, social, environmental, and technical aspects. This allows the reader to form a more unified view of each. In addition, it is clearly stated that none offers the only, best solution.

In the area of energy, it is most difficult to discuss anything realistically in terms of the "next five years." As mentioned earlier, the authors of the NAS volume essentially make no attempt to confine their comments to five years hence. Examples of this can be found on many pages: "Many of our energy consumption systems cannot be substantially changed in one or two decades," (Pg. 254), "In the next two or three decades. . ." (Pg. 256), and so on. These clearly point out some of the problems the NAS had with the 5-year time frame.

and deficiencies are brought to light. It is important that we are reminded that, "solar energy conversion systems require considerable investment in non-renewable and energy-intensive resources which offsets the abundance and cheapness of the energy source itself." (Pg. 71 NSF)

The discussion in the NAS volume of government activities necessary to further the safe use of nuclear power is conclusive and enlightening. Nuclear power is becoming increasingly a social and political problem, and this section is well suited to cover the political aspects. More sections of this type are needed.

Even allowing for the short time allowed for the writing of the bulk of this material, there are a couple of noteworthy omissions. One, which the director of NSF mentions briefly in his introduction, is the importance of non-energy uses of oil and gas. As he says, "Petroleum is far more valuable as the basis for organic industrial products (including fertilizers, plastics and pharmaceuticals) than as a fuel." (Pg. 19 NSF) It is important to understand the forces between energy and non-energy uses of our resources and how best to handle them.

Besides combustion and all the problems surrounding nuclear power, there are other aspects of the "energy chain" that should also be considered when discussing

pollution. Some examples are production (offshore drilling particularly) and transportation of products (pipelines, docking facilities, LNG, etc.).

After noting the duplication of topics in the commissioned papers (two papers on crime, two on privacy, two on state and local governments), it appears absolutely unpardonable that not a single paper on energy is included. If any emphasis at all is placed on the comments of informed individuals then certainly we should expect an "energy paper."

A final observation is that a huge but vague burden is being placed on "research and development." This almost fairy-tale panacea is present in other sections as well. There should be mention, where applicable, of problems that R & D cannot solve and must therefore be handled in other ways. And for those areas for which technology appears to have the greatest potential for contributing, specifics should be given. Only the statements by the DOE use such specifics as ". . . advanced catalysts for liquefying coal."

III. A FORWARD LOOK

Assuming that this process of bringing Congress up to date with the issues surrounding science and technology will continue, it may be helpful to mention some

ideas for future presentations.

It is clear that a better definition of what is needed is mandatory. More specifically, what do policy makers want most that will help them with their duties: strictly facts and figures ("our coal reserves will last at least 100 years"), or a summary of social, political, economic, and technical issues ("our dependence on foreign oil puts us in economic jeopardy"), or actual policy recommendations ("all regulation of American oil industry should stop"). If they want all of these things, then it would make sense to clearly divide the tasks to avoid the redundancy and incompleteness that arises if everyone tries to write about everything.

Moreover, there should be an outline of specific goals or objectives in each submittal. Statements such as the "NRC is actively working on certain problems deemed to be of national significance," (Introduction to NRC submittal) would not be tolerated. Rather, the approach taken by the Department of Energy should be emulated where each section concludes with the ultimate goal of the DOE strategy in the particular area, as well as what the authors repetitively term, "fundamental objectives."

If papers from informed individuals outside the government are to be commissioned, then all duplicity

should be avoided. The topics should be well defined so that the author will not repeat work being done elsewhere (this is quite painfully not the case here). These observations from "outsiders" may be the most helpful of all the documents in defining policy possibilities.

It is crucial to have a portion of the finished material where all supporting work can be brought together, synthesized, in a succinct but complete manner. Since it can't have everything in it, the statistics and explanations of technologies should remain in the supporting material leaving room for thorough treatment of the issues. The NSF Vol. I is a first approximation to this but often falls short by portraying a too simplistic set of problems and solutions. The fact that it is a compilation and a distillation of the reams of supporting material means that it will probably be this portion of the final report that most recipients read. It should, therefore, set out in no uncertain terms what areas are in need of immediate legislative investigation or action.

Finally, the authors of the material should be encouraged to use a standard format (grammar, structure, and content) so that the readers will never need to wade through pages of peripheral text to get to the area in which he/she is interested. The tendencies for

pontification and self-justification should be strongly discouraged.

A FIVE YEAR OUTLOOK

A Critique on
the Topic of
HEALTH

Georgia Institute of Technology
Spring, 1980

Bo Bowden
Thomas Rhodes

A GENERAL OVERVIEW

In an effort to stay in touch with the latest developments in technological and scientific activities, Congress has opted to somewhat relieve themselves of this enormous burden by calling for a thorough publication composed of expert analysis. Though legislators must be complimented for the realization that they cannot offer authoritative decisions on such matters without expert assistance, the actual documentation must be severely reviewed in terms of its efficiency in meeting this crucial necessity.

A general overview of the many topics covered readily indicates these subjects were indeed handled differently by their respective authors, in regards to interpretation of purpose. One must first question if the "five year outlook" subtopic were a mere afterthought included immediately prior to printing. Examples abound throughout the writings where a time frame of 25 years has been adapted, drastically accelerating our perspective into the 21st century. (see p. 412, NAS) This point consequently questions a five year limitation, as "most technological innovations that are likely to be available in five years are already, today, in an advanced stage of development." (p. 45, NSF Vol.1) The writers obviously feel such a time frame is much too constraining as they subconsciously stretch their boundaries.

Another clue as to the uncertainty of purpose are the various conflicts being created among topics by offering solutions to problems without regards to relating fields. For example, proposed remedies for meeting escalating demands for energy call for massive strip-mining operations, a solution intolerable among environmentalists, or an increase in nuclear power plant construction, a measure looked upon disdainfully by health officials, who are quick to point out 70% of all cancers may be traced to

environmental causes. These rampant discrepancies strongly indicate a severe alienation among authors.

A final observation proving the general uncertainty of the assignment at hand is the multiple formats adapted by different writers. Unfortunately, most choose to adjust to an explanatory approach rather than concerning themselves with the requested material beneficial to future decision making.

All in all, these documents lack a structural bond, or "grammatical glue," which would alleviate the severe problems of randomness and absence of consistency. Such a professional report, especially addressed to an audience of top officials, need possess an overriding theme of common purposeness, with each participant conforming to a more organized pattern.

DOCUMENTS CONCERNING HEALTH

Although a general format problem has been highlighted, the NAS chapter addressing health must be complimented on a noble attempt. The broad spectrum encompassing health issues and related subjects has been divided into smaller, more manageable portions for discussion purposes. A topic is introduced, defined, and then more readily explained utilizing gathered data and statistics so that the reader might better comprehend the options available for future progress.

Unfortunately, this particular format approach fails in two respects. Primarily, the audience moves rapidly from topic to topic without receiving a concrete, conclusive statement in terms of the most beneficial course of action. Abstract phrases such as, "achievement of a deeper understanding," (p. 426, NAS) "serious efforts will be made,"

(p. 427, NAS) and "studies will expand," (p. 432, NAS) appear to be hastily attached onto various subjects as afterthoughts, and offer minimal enlightening information to the reader, curious of remedies being pursued. Although the NSF Volume 1 admirably provides helpful, informative data, it quickly overshadows any redeeming qualities with solutions calling for, "enhancing effectiveness," (p. 25) "supporting improvements," (p.25) and "augmenting our knowledge. (p. 26)

Secondly, the statistics offered become more of a medical documentary than a five year outlook. These reviews would be most acceptable if they were used for analysis and forecasting purposes, however, retrospective research into the "past quarter century" (p. 404, NAS) are introduced and "dropped" without proposing any prophetic assistance. Similarly, a table introduced illustrating a breakdown on the causes of death covers the years 1900, 1940, and 1975. (p. 384, NAS) Again, no indication whatsoever is made as to how these figures might affect future outlooks.

Though granted, we are dealing with highly technical material which involves a distinct and exclusive scientific vocabulary, the health documents frequently adapt the appearance of a pre-med textbook, as they assume audience ignorance on various subject matter and hasten to discuss in lengthy detail. Unfortunately, this approach accounts for a majority of the material, and leaves any form of an outlook to assume a secondary role. In keeping with the purpose of these writings, tangible solutions to mental health, for example, should be described rather than emphasizing that the "human brain is composed of ten billion nerve cells." (p. 408, NAS)

Closely relating to this complaint is the repititious incorporation of medical phrases such as psychopharmacolo-

gical therapy, neurotransmitters and tricyclic antidepressants. These "operating room" terms in their undefined state serve only to further confuse the audience of the topic at hand.

Though the agency statements are much improved in describing particular courses of future research, they too fall into the dismal habit of introducing such beauties as immunohistochemistry, B-endorphins, and L-alphaacetylmethadol.

In particular, the NAS Volume desperately needs to be edited of dozens of irrelevant remarks which serve little purpose in such a sophisticated collection of technical material. Though statements which discuss "leukemia in cats," (p. 397, NAS) and announce that "sudden death is the first symptom," (p. 393, NAS) become more humorous when taken out of context, the fact is that the writers have been issued a strict allotment of space in which to organize a thorough outlook of the health field. Many statements such as these which provide no astounding revelations need to be omitted.

OMISSIONS

Though the authors of these documents must condense an enormous conglomeration of material into a fractional portion, several topics imperative for a more complete report must be considered for future efforts. The NAS and NSF Volumes fail to mention governmental regulations or intervention, which might greatly assist in solving the health care delivery question concerning rural and low-income populations. Socialized medicine, and the alarming lower mortality among whites (than non-whites) are similar social issues labeled "hands off," but must be addressed in the near future if a total health care

perspective is to be confronted.

Another issue common to the fields of social health and government is the rapid emphasis and consideration being given to handicapped persons. Intense legislation has produced such documents as the "Affirmative Action Obligations of Contractors for Handicapped Workers,"* which legally prevents discrimination against the disabled in the workplace, as well as in a public facility in terms of design. Such a topic which involves some 35 million people and millions of tax dollars annually cannot be easily ignored.

A final, yet most crucial omission common to the Health documents pertains to the economical aspect. Dr. Kenneth Warner (The Role of Science and Technology In the Containment of Health Care Costs) stresses that health costs are today's single most discussed health

care issue, gradually expanding to 9% of the gross national product, at present. This figure corresponds to 162.6 billion dollars, or \$736.92 per person in the United States.** Once again, costs of such magnitude cannot be simply overlooked. Cost containment strategies play a vital role in future outlooks and must be addressed.

HIGHLIGHTS

Temporarily overlooking the numerous complaints registered above, the NAS Volume does in fact hold two admirable features. It provides an excellent section concerning depression in the elderly, and the psychological dilemmas caused by retirement. The volume interestingly

*Federal Register Volume 41, No. 75, pages 16147-16155 4/16/76

**Health-United States 1978 Dept. HEW, PHS publication 78-1232

points out that a major concern of the health field is the social problems encountered by the nation's senior citizens. This topic also covers probable causes of functional dependency, as well as offering solutions to subdue the widening gap between medical and social services among the aged.

The NAS Volume Chapter 8 (Health) also possesses perhaps the most complete conclusive outlook among the various documents. Although 4 $\frac{1}{2}$ pages effectively concludes 48 pages of material in an organized fashion, it should preferably ^{HAVE} been an edited accumulation of previous points rather than freshly-introduced suggestions.

PROPOSALS

If this publication is to indeed become a continual process to assist the U.S. Congress in the areas of science and technology, several proposals for future endeavors might prove helpful.

In general, an overall statement of purpose is critical to producing a report with common cause, characterized by a consistent format. Specifically, should the authors maintain a "big picture" approach, reinforced by bias demonstrations of their expertise in the particular field, or should they adapt a more elementary style, which would simply state recommendations for future directions? It would seem an outline of specific goals and objectives would be in order as the material is designed primarily to answer the inevitable question, "what lies ahead?"

As an example, the following are listed as priority activities in the field of health.***

family planning
contraceptive efficiency
prenatal care
postnatal care
childhood immunization
high blood pressure control
toxic agent control
occupational health control
accidental health control
infectious aid control
smoking cessation
reducing alcohol and drug abuse
improved nutrition
exercise and fitness
stress control

Not only does such an objective study indicate a definite strategy planned by the agencies and officials, but its conciseness and clarity more readily enables the audience to easily interpret problem areas, and their significance on a comparative basis.

Such an approach might effectively discourage the author's tendency to provide unnecessary information and opinionated viewpoints, and eliminate the unbearable quantities of useless technical commentary.